A PRELIMINARY REPORT ON THE STUDY OF THE ABATEMENT OF AIR POLLUTION FROM WINTER SANDING OPERATIONS IN MONTANA

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GLOSSARY

Ambient Air:	Unenclosed, outdoor air
Dust:	Particles small enough to pass a 100 mesh sieve or about 150 μ in diameter
μ:	Micron; one millionth of a meter or about 1/25,000 inch
$\mu g/M^3$:	Micrograms per cubic meter; one microgram is one millionth of a gram or about 1/28,000,000 ounce; one cubic metre is a little greater than one cubic yard, approximately 35 cubic feet
Quartzitic:	Having a significant amount of quartz in its composition
Sand:	Granular material derived from the breakdown of rock, also antiskid material used on snow and ice covered roads and streets
Silica:	SiO_2; quartz is the most common form of silica

I. INTRODUCTION

This report is intended to present the preliminary findings concerning the air pollution problems and solutions associated with winter sanding operations in Montana. The approaches suggested in this report are of a very broad nature and are intended only as suggestions to all persons involved in the winter sanding air pollution problem.

The federal ambient air standards for suspended particulate matter allow no more than 60 $\mu g/M^3$ (secondary standard) as an annual average. Annual averages of over 100 $\mu g/M^3$ are common and values in excess of ten times the standard have been recorded. Sampling done by the Department of Health and Environmental Sciences shows that a very large portion of this dust is from the streets. Of the total street dust, a large part comes from winter sanding operations.

The airborne dust generally contains a large amount of silica (mostly quartz) and silicates. People subjected to free silica dust in large enough quantities over a period of time contact silicosis and related diseases. It appears that the level of particulate matter in some of our cities often exceeds the amount necessary to produce silicosis (Drinker and Hatch, 1954). In addition to silicosis, there are other diseases and conditions brought on by or aggravated by dust. The nuisance factor and aesthetics of this dust problem alone, should be sufficient to bring to an end, the unsatisfactory sanding practices now used in many communities.

II. SOURCE OF DUST THAT BECOMES AIRBORNE

The word "dust" will be applied to particles small enough to pass a 100 mesh sieve or about 150 μ and smaller. Particulate matter larger than this size will quickly settle from the air except in high wind, and does not usually represent an air pollution problem. The size limit of approximately 150 μ has also been used in previous works concerned with dust problems (Drinker, 1930).

Dust from winter sanding operations comes about in two ways. The first is the dust that is applied directly to the streets during application of the "sand". The second, is the dust that is created by the tires of the vehicles while the sanding material is on the street surface. As long as this dust remains on the street, it is no air pollution problem, but particles smaller than 150 μ can become airborne quite easily. Moving vehicles, people walking, and similar traffic disturb the loose material allowing the lightest breeze to carry the dust over the land.

To determine how much dust was applied to the streets in the sanding operations, samples of sanding material were obtained from the city stockpiles in Great Falls, Billings, Missoula, Butte, and Helena. These samples were subjected to sieve analyses by the Montana State Highway Department. (Figure 1)

Because it is the practice of most communities to use the cheapest, most readily available materials for sanding, each community has a different source. Great Falls had stockpiled waste fines from a rock crusher which consisted of 20% dust. Butte obtained their sanding material from a natural deposit on the valley floor near the city. Only about seven percent of this natural deposit is dust. The cities of Missoula and Billings had stockpiled sand and gravel for use in winter sanding, asphalt mix, and similar type purposes. This material had been sized and its origin is not known. The city of Helena uses the excess chips from its paving operations which it picks up from the

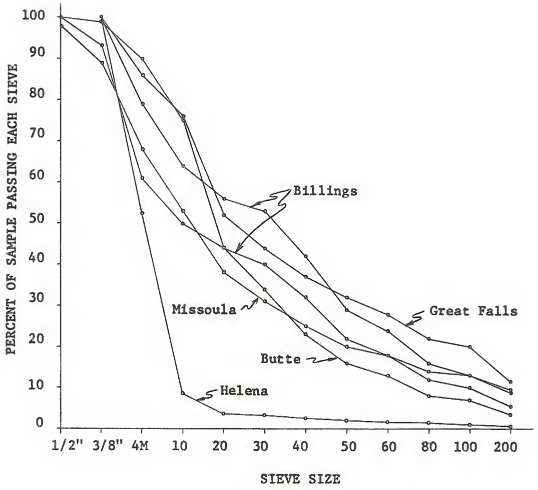

FIGURE 1 Sieve analyses of street sanding material obtained from the stockpiles of five Montana cities.

streets and stockpiles for sanding operations. Only about one percent of the Helena "sand" was dust. In all these cases, the sanding material seemed to be quartzitic in composition. None of the cities had stockpiled cinders or similar soft material when the sampling was done (October 1971), but there were comments made in one city that there would not be enough of the material stockpiled to last through the winter and material of a quite different nature may have been used on the streets.

Questionnaires were sent to all the cities and towns in Montana with populations greater than 1,200, except the largest cities (about 41 communities). Completed questionnaires were returned by 27 communities on which they indicated their winter sanding practices. All but one of the 27 indicated they use "sand" on the streets in the winter. The stated sources of the sanding material varied considerably, but exact sources and compositions could not be determined from the questionnaire. It is reasonable to assume that the raw material contained a considerable amount of dust in most cases--similar to the values obtained from the Butte and Great Falls samples. Of the 26 communities using sanding material, 18 claimed that there is no treatment of the raw material; thus, no dust removal. The communities applying untreated sanding material to the streets claim to use as much as 750 tons of this material per winter. Assuming that this material is 10 percent dust (a conservative figure), 75 tons of dust is directly applied to the streets of one community! It should also be noted that the eight communities that use treated "sand" do not necessarily remove very much of the dust before the material is applied to the street.

That dust which is directly applied to the streets, however, is not the only dust that may become airborne. A significant if not, in some cases, the major source of dust on the streets comes about by the grinding of the antiskid material by the tires of the vehicles. A parking lot near the State Capitol Building was observed through the winter of 71-72. The city of Helena applied the antiskid material through December, January, and into February. There was little snow through February and essentially none in March until after a sample of the "sand" was taken on March 15. The size distribution of the sand, when applied to the parking lot, was very close to the size distribution in the sample obtained from the Helena stockpile. Figure 2 shows a comparison of the two Helena samples and a sample from the Missoula stockpiles. It can be seen that even though only about one percent of the sand applied to the parking lot was dust, by the middle of March, 16% of the sand lying on the lot was dust. The dust that had been carried away by running water from rain and melting snow and by the wind was not in the sample. It is therefore possible that the actual percentage of the applied sand that became dust well exceeded 20%. The dust passing the 200 mesh sieve in the parking lot sample exceeds even the amount in the Great Falls sample. An examination of the material in the parking lot showed that the sand had a high percentage of quartz in its composition. Therefore, the size distribution and composition of the antiskid material as it was applied to the parking lot in Helena was as good as can be expected. Better washing and the use of pure quartzite may produce better sanding material but this material is not available to the majority of communities in Montana.

From these data, it can be seen that the air pollution problems associated with winter sanding in Montana may be reduced, but not eliminated, simply by reducing the dust in the applied "sand". Street

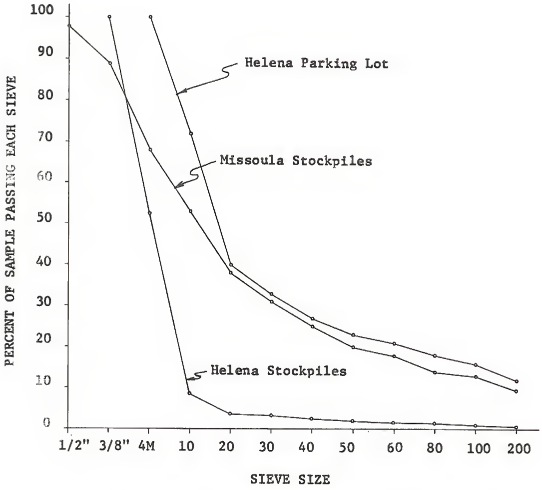

FIGURE 2 Sieve analysis data illustrating changes in size distribution of antiskid material while exposed to traffic on the pavement.

cleaning must be done as soon as the snow and ice melt and the sweepers can begin to work. The longer the loose antiskid material lies on the street, the greater the air pollution problem becomes. One other benefit derived from street sweeping is the removal of particles large enough to roll under the tires as ball bearings and produce skidding of the vehicles.

III. APPROACHES TO REDUCE DUST FROM WINTER SANDING OPERATIONS

To reduce or eliminate the airborne dust that presently originates from winter street sanding operations, the municipalities should adopt one or more of the following approaches:

1. Eliminate the use of all "sand"
2. Apply only a limited amount of sand
3. Apply sand with an absolute minimum of fines
4. Apply sand only of quartzitic or granitic composition
5. Clean and sweep streets of all dust and dust producing material

Elimination of Sanding Operations

The application of sand to lightly used streets is unnecessary in many cases. A certain amount of traction loss on roads and streets is inevitable in winter. With proper driving techniques and reasonable care, level streets in small towns can be easily traversed without the use of antiskid material. In larger cities where there is heavy traffic on the streets and where streets are built on hills, slippery streets are more critical and pose more of a safety hazard and inconvenience.

When snow and ice on the street necessitates an action, alternatives exist to sanding. The snow may be removed physically by plowing or scraping or it may be melted by the use of salt. Sanding does not reduce the amount of snow on a street except perhaps by producing a darker surface to absorb more radiant energy from the sun. Rutting and associated conditions develop which are hazardous in themselves and cannot be eliminated by the application of antiskid material. These conditions can only be corrected by the actual removal of the snow and ice. The plowing of snow from traveled portions of streets is a method which is little used in Montana. Early plowing after or during a snowfall will reduce the snow on the streets and will allow a period of mild temperatures to produce a dry clean surface. With less snow on the street, the entire situation is improved, whether further treatment is used or not.

Further treatment after plowing need not involve sanding either. In many parts of the country, salt is used exclusively. However, in recent years, a considerable amount of criticism has been aimed at the use of salt. The greatest criticism has been the pollution of groundwater, surface waters, and the soil adjacent to the street or roadway. Severe chloride pollution resulting in the killing of plant and aquatic and terrestrial animal life is well documented. The heavy use of salt in Montana could pose an even bigger environmental hazard due to the more arid climate. Serious groundwater pollution and the killing of trees has been occurring where the annual rainfall is in the order of 40 inches and more (Whittle, 1971). In Montana, the annual rainfall is in the order of 10 to 15 inches a year in many communities. With a much lower annual rainfall in Montana, much less salt would be required to achieve the same degree of pollution as in northeastern United States. Mrs. Whittle (1971) also points out the extent of property and highway damage that is brought on by the excessive use of salt. She (written communication) also states that from 15 to 50% of the airborne particulate matter near Boston University in Boston is salt. It would not be wise to replace the siliceous air pollution with a combination of salt-produced air and water pollution. Eighteen of the responding 27 Montana communities claim to use some salt. In general, they use salt sparingly and do not begin to approach the amount used in Newton, Massachusetts (32 tons per mile of street in the winter of 1970-71) (Whittle, 1971). Some of the communities in Montana mix the salt with the sand, but almost half indicated they use salt by itself at times. The city of Lewistown claims not to use any sand, although the State Highway Department uses sand on the streets that they maintain in Lewistown. About ten tons of salt are used per year by the city. The city of Bozeman indicated they seldom use sand.

For best results, salt should be used when the temperature is near the freezing point. When the temperature is lower, it requires more and more salt to melt a given amount of ice. When the temperature is much below freezing, the use of salt should be curtailed. Fortunately, there is a rise in the coefficient of friction of ice at these lower temperatures.

For a given street or neighborhood, there are alternatives to sanding if the inconvenience and/or safety factor of a snow and ice covered street make it mandatory to act. Plowing and/or placing a small amount of salt on the surface can often alleviate the problem.

Applying a Limited Amount of Sand to the Streets

It follows that the less sand that is placed upon the streets, the less air pollution will result. Sand can be indiscriminately spread over all streets until the supply is exhausted or the end of the workday is reached. A little planning with some thought as to where the sand is most needed will result in less sand being applied to the streets with no reduction of its benefits. It may be decided to sand only at intersections and on hills. In this case, perhaps only 20% of the sand would be spread as if all street surfaces were to be covered.

The size of the particles in the sand also affect the sand's usefulness. A coarse sand will lie in a parking lot and be useful through numerous light snowfalls. That same sand size may be hazardous and ineffective on a high speed expressway.

Sanding crews should be able to evaluate the need for sand on any particular street, especially after light snow when the sand from previous applications may still be effective, in which case, excessive sand will be used if more is applied.

Sand is applied to increase the friction between the tires and the ice covered street. Up to a point, the more sand that is applied, the greater the friction. Here, the point is not to try to create conditions as favorable as summertime road surfaces but to provide a reasonable degree of convenience and safety for winter driving. Again, proper driving techniques and reasonable care by the drivers cannot be supplanted by sand on the streets.

A given value of friction on a street may be achieved efficiently or with a great waste of resources. Not all sand sizes have the same antiskid values. Hegmon and Meyer (1968) found that the highest coefficient of friction was obtained by particles from sieve sizes of 4 to 16. They also state that particles passing a 50 mesh sieve (300 μ) are of little use and should be eliminated from the sand, (Figure 3). By this criteria, 32% of the sand sampled at Great Falls and applied to the streets is wasted. Sixteen percent of the Butte sample is also too fine to be of use on the streets. This excess material is costly to store and to apply and is a ready source of air pollution. For every two tons of effective sand that is applied to the streets in Great Falls, an extra ton is stored, loaded, hauled, and applied.

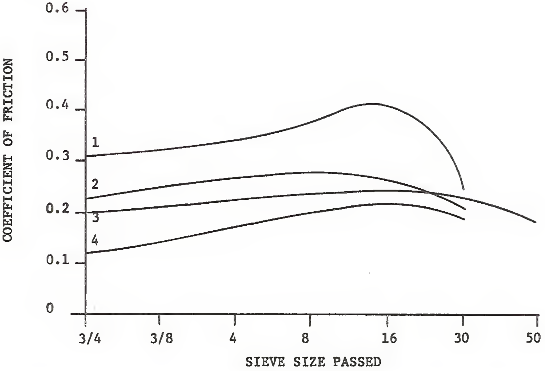

FIGURE 3 Coefficient of fraction for antiskid materials of various size fractions. (from Hegmon and Meyer, 1968)

1. Coke cinders on snow, first wheel pass

2. Coke cinders on snow, after four wheel passes

3. Boiler cinders on ice, first wheel pass

4. Coke cinders on ice, first wheel pass

Apply Sand with an Absolute Minimum of Fines

From a previous section in this report, it was pointed out that a portion of the dust on the street is directly applied by the spreading vehicle. It is then quite desirable to eliminate as much of this dust from the sand as possible prior to application to the street. It was also pointed out that all that sand passing a 50 mesh sieve is of little or no use as an antiskid material.

It is the common practice of communities and the State Highway Department to use the cheapest, most convenient sanding material available. In many cases this practice would be quite satisfactory if the fines could be removed. Certainly a community cannot be expected to haul this sanding material any great distance. Since any additional hauling and cleaning raises the cost of the sand, the use of sand may be restricted to those times and places where it is most needed. It should also be emphasized that less clean sand would be required to achieve a certain value of road friction than if untreated sand were used. The savings involved in handling a smaller quantity of sand would certainly help defray the cost of cleaning. Eight of the communities responding to the questionnaire do treat, in some way, the sand they use. From some isolated observations, it is likely that very few communities clean the sand to a desirable degree. The city of Helena uses a sand that is as good as can be expected. This sand is obtained by using excess chips from street paving operations in the summer. The sand is swept from the street by street sweepers and is then stockpiled. The cleanest material can be used in future paving operations, but most of it is unsuitable for this purpose and is used as antiskid material. There are plans to obtain the necessary equipment to wash the sand and use it over again. There are, presumably, other communities that would have a similar source of sand available to them if they choose to use it.

The cleaning of any sand requires some equipment. A mobile type of washer that could move from community to community during the summer could process the antiskid material for a number of communities. In this way, a number of communities would share the cost of the equipment.

Perhaps other means exist to eliminate the fines in the applied sand. The methods used will depend upon the community and its nearness to suitable sources. In any case, no community should use sand consisting of such large percentages of fines as that which is used today by many communities.

Composition of Sanding Material

How quickly the antiskid material breaks down into dust under the tires of vehicles, depends upon the strength of the grains. Grains of quartz are much stronger than those of cinders or shale fragments. Sand with a high quartz content (providing the quartz grains are reasonably large) is about as durable as any material commonly available. This generalization does not necessarily apply to crushed sandstone. Some sandstones are poorly cemented (that is, the grains are weakly held together) and may contain large amounts of clay. Other sandstones, known as quartzites, are very durable but may be costly to crush. Shales contain large amounts of clay and fragments of shale are soft and break up very quickly. The clay and dust from shale can actually create slippery conditions when this material gets wet. Crushed shale should never be used as antiskid material.

In addition to natural materials, cinders, slag and other man-produced materials have been used for antiskid purposes. Some of these materials are quite durable but some (for instance, cinders) break down very quickly and produce great quantities of dust. When this dust is black, it is especially undesirable, aesthetically.

Unfortunately for our present purposes, geological materials are not evenly distributed across the state. There are communities that do not have easy access to good quality sanding material. Most communities, however, have natural deposits of aggregates nearby. Normally, good deposits of sand can be obtained from present or ancient stream channels. Old lake beds and glacial deposits may also yield good supplies of sand.

The durability of sanding material can be measured by the Los Angeles Wear Test (AASHO T-96 or ASTM C-131). This test is used by the State Highway Department laboratory to determine the acceptability of concrete aggregate. The values that would be acceptable from this test have not yet been established but may be included in specifications at some future time.

In summary, the composition of sanding material must be considered when planning for winter sanding operations. The best material available should be used.

Clean and Sweep Streets

As was shown by the parking lot in Helena, even the best sanding procedures outlined above are of little value if the sand is not quickly removed from the street. The most durable antiskid material quickly wears down into dust. The necessity of cleaning all streets, parking lots, etc. cannot be stressed too strongly.

Of the 27 communities responding to the questionnaire, only one stated that they did not sweep or clean the streets. However, a maximum effort should be placed on street cleaning as soon as the ice melts and the streets become dry. On one visit to one of the larger cities, a number of sweepers were seen sitting idle. The author was also told that not all of the streets in the surburbs in this city were swept during the summer. Even though this city could boast a large number of sweepers, it was obvious that little emphasis was placed on their use. The cleanliness of a town is not dependent upon the number of sweepers it owns but upon the use of the sweepers and other cleaning methods. All of the sanding material placed upon the streets during the winter should be cleaned up within a few weeks after sweeping can commence. Sweeping also reduces the amount of material that goes into the storm sewers and often leads to their being clogged.

The sweeping and cleaning operations are lessened by following the recommendations outlined above. By limited and wise use of sand, there will be considerably less time and expense involved in the spring clean-up.

Small communities near to or adjacent to larger cities could make arrangements for joint use of the sweepers. There are a number of small towns in Montana which could benefit by this type of arrangement.

The most important approach to reducing airborne dust from winter sanding operations is the early and complete sweeping and cleaning of the streets of all unconsolidated sand and dust. If antiskid material is allowed to lie on the street through the spring and summer while being subjected to the grinding action of vehicles, all other efforts in improving the environment will be hidden behind a cloud of choking street dust.

CONCLUSION

Much of the airborne particulate matter in the air in the communities in Montana originates from winter sanding operations. Changes in sanding operations can eliminate much of this problem. Wise decisions concerning the winter street maintenance and the use of sand of better quality and size distribution will reduce street dust while reducing the inconvenience and hazards of winter driving. Proper sweeping and cleaning of the street after they become clear of snow and ice is also mandatory if the dust problem is to be solved.

Each community must examine their winter street practices in light of their needs and resources. Improvements and changes that are satisfactory for one community or part of the state may not be applicable to the entire state. For this reason, it is best for the communities to work out suitable programs at the local level and not require the state to impose an overall program to apply statewide. It is essential that the airborne dust problem be solved to the best of our ability.

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